HYCOM Caspian Sea Modeling.

Part I: An Overview of the Model and Coastal Upwelling

By

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MOTIVATION

- **Caspian Sea model set up**

    o **Resolution, vertical layers, atmospheric forcing, etc**

- **Upwelling along the eastern coast**

    o **ability of HYCOM in producing upwelling**

- **Hybrid versus sigma–z simulations**

    o **do they succesfully generate the upwelling ?**

FINE RESOLUTION OGCMs

● The Caspian Sea is NOT included in majority of OGCMs

| Resolution	OGCMs excluding the Caspian Sea
1/32°	NLOM (Wallcraft et al., 2003) NRL Layered Ocean Model
1/16°	MFSTEP (Pinardi et al., 2003) Mediterranean Forecasting System
1/12°	HYCOM (Chassignet et al., 2006) HYbrid Coordinate Ocean Model
1/12°	DMI (Buch and She, 2005) Danish Meteorological Institute
1/8°	NCOM (Barron et al., 2006) Navy Coastal Ocean Model
1/3°	MERCATOR (Ferry et al., 2005) Mercator Ocean

HYCOM SET UP FOR THE CASPIAN SEA

Grid resolution:	$[1/25° \cos(\text{lat}) \times 1/25°]$ ≈ 3.2 km
Vertical layers:	Two configurations 25 layer hybrid and 30 level sigma–z
Initialization:	Russian data–based T/S climatology
Mixed layer:	K–Profile Parameterization (KPP)
Bathymetry:	Modified DBDB–2 with the Russian data
Bottom layer:	Active bottom boundary layer
Atm. forcing:	ERA–40 climatology (1979–2002)
River forcing:	Three major rivers as runoff
Turbidity:	SeaWiFS ocean color data
Bulk formulas:	Sensible and latent heat fluxes
Relaxation:	Sea surface salinity only
Assimilation:	None

BOTTOM TOPOGRAPHY
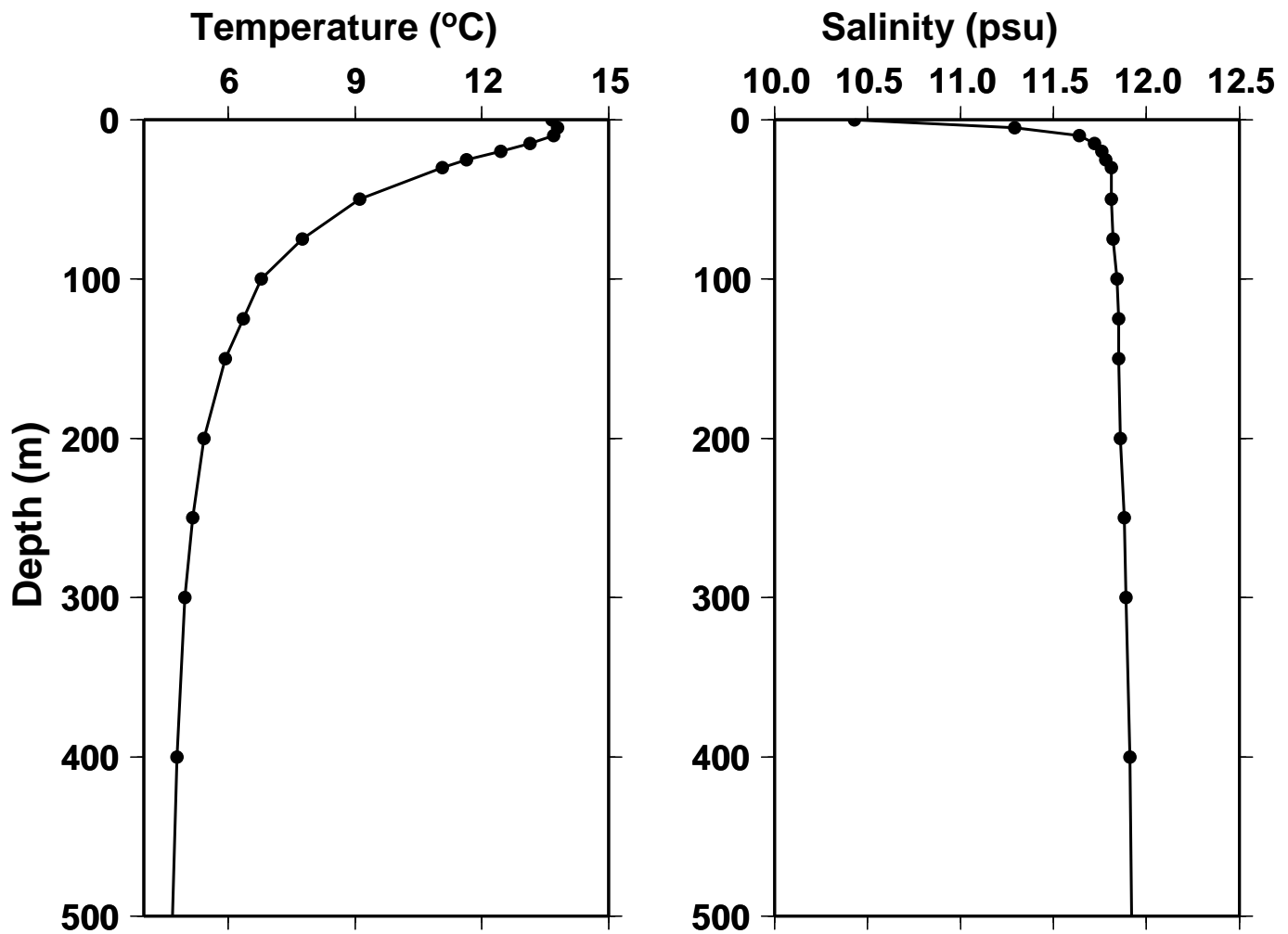
(a) Full bathymetry (m)
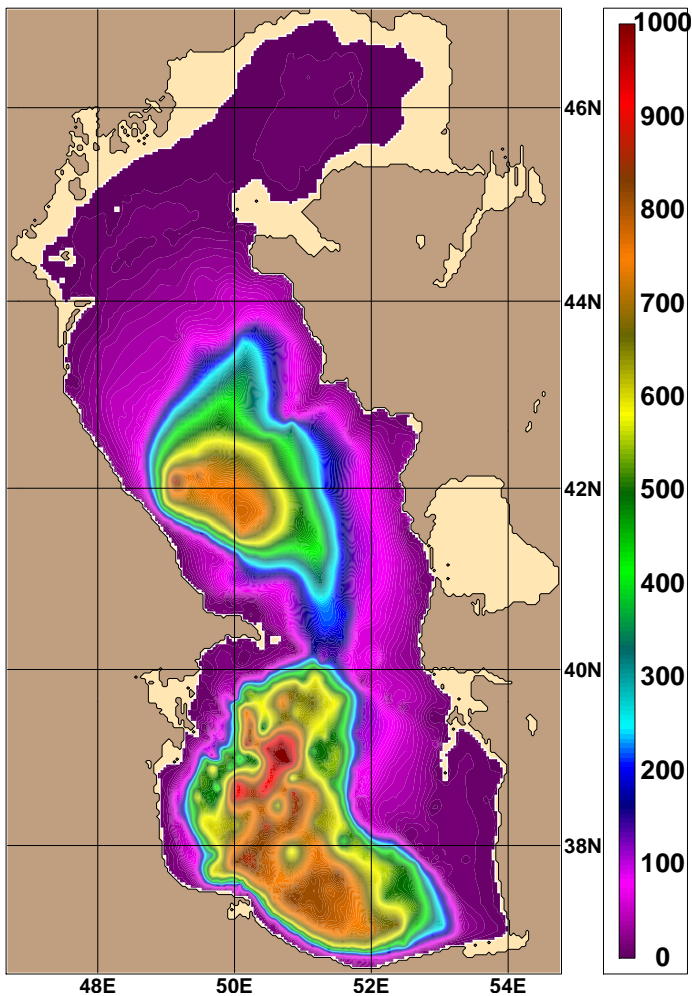
## (b) Shallow regions (m)
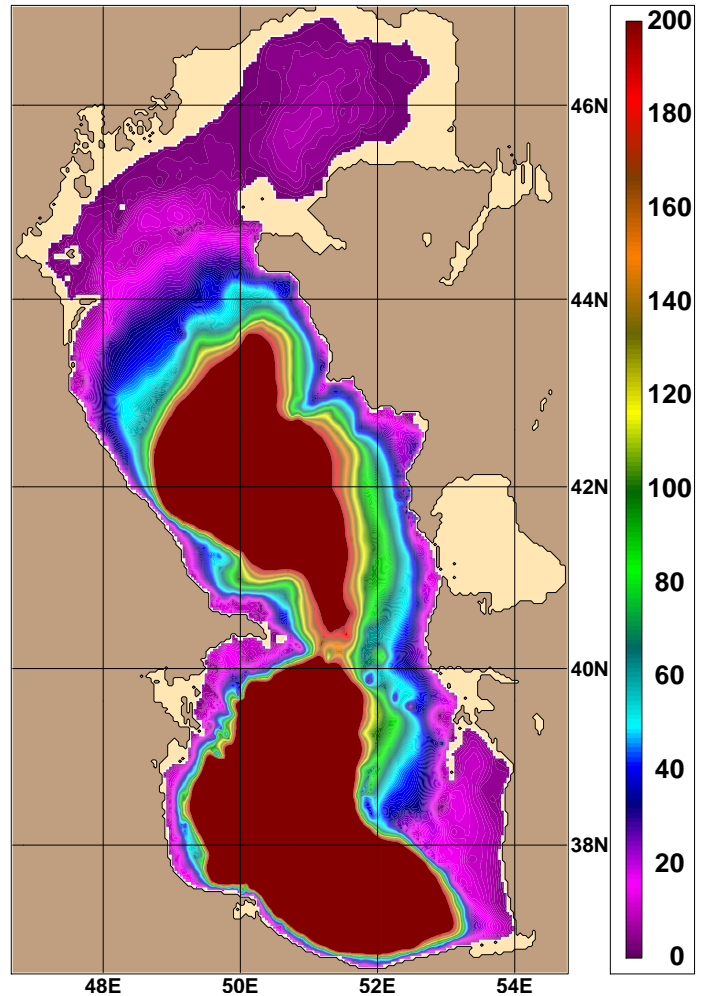
- **DBDB–2 in the Caspian Sea is not correct.**

- **The Russian data set was used to modify it.**

  o **HYCOM uses land–sea isobath of 2 m.**

  o **Maximum depth is $\approx$ 1015 m.**

TEMPERATURE and SALINITY INITIALIZATION

- **Basin–averaged T/S from the Russian data**

- **Temperature gradually drops with depth.**

- **Salinity is constant ≈ 11.8 psu below 50 m.**

- **Temperature has more effect on density.**

RIVER DISCHARGE IN THE CASPIAN SEA
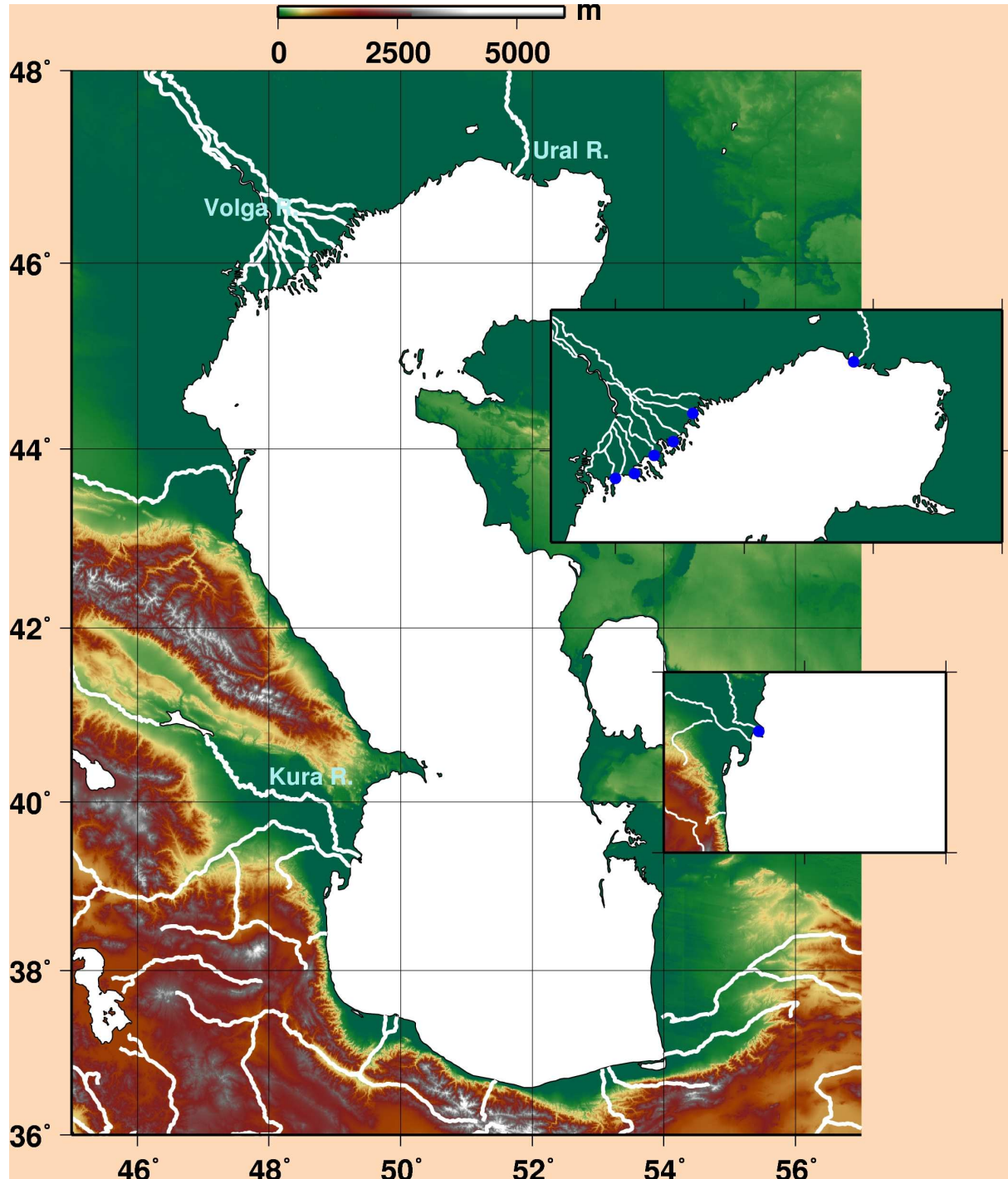
- **HYCOM reads in monthly mean river discharges.**

- **Runoff addition to the surface precipitation field.**

HYCOM SIMULATIONS

- Use KPP mixed layer model

- Perform climatologically–forced simulations

- Run 5 years until statistical equilibrium

- Run another 4 years and form monthly means

- As mentioned before, there is

    - no data assimilation, and

    - no relaxation except for sea surface salinity.

SENSITIVITY SIMULATIONS

What is the importance of heat and salinity fluxes

in simulating upper ocean quantities in the Caspian Sea?

Note: Net buoyancy flux is the sum of

     o **buoyancy due to heat flux and**

     o **buoyancy due to salinity (i.e., E–P) flux.**

● **Four sensitivity simulations:**

     o **expt 1: standard simulation (30 level sigma–z)**

     o **expt 2: twin of expt 1 but no salinity relaxation**

     o **expt 3: twin of expt 1 but no E–P**

     o **expt 4: twin of expt 1 but no rivers**

     o **expt 5: twin of expt 1 but no E–P and no rivers**

DEPTH–AVERAGED VARIABLES

February

- expt 1
- expt 2
- expt 3
- expt 4
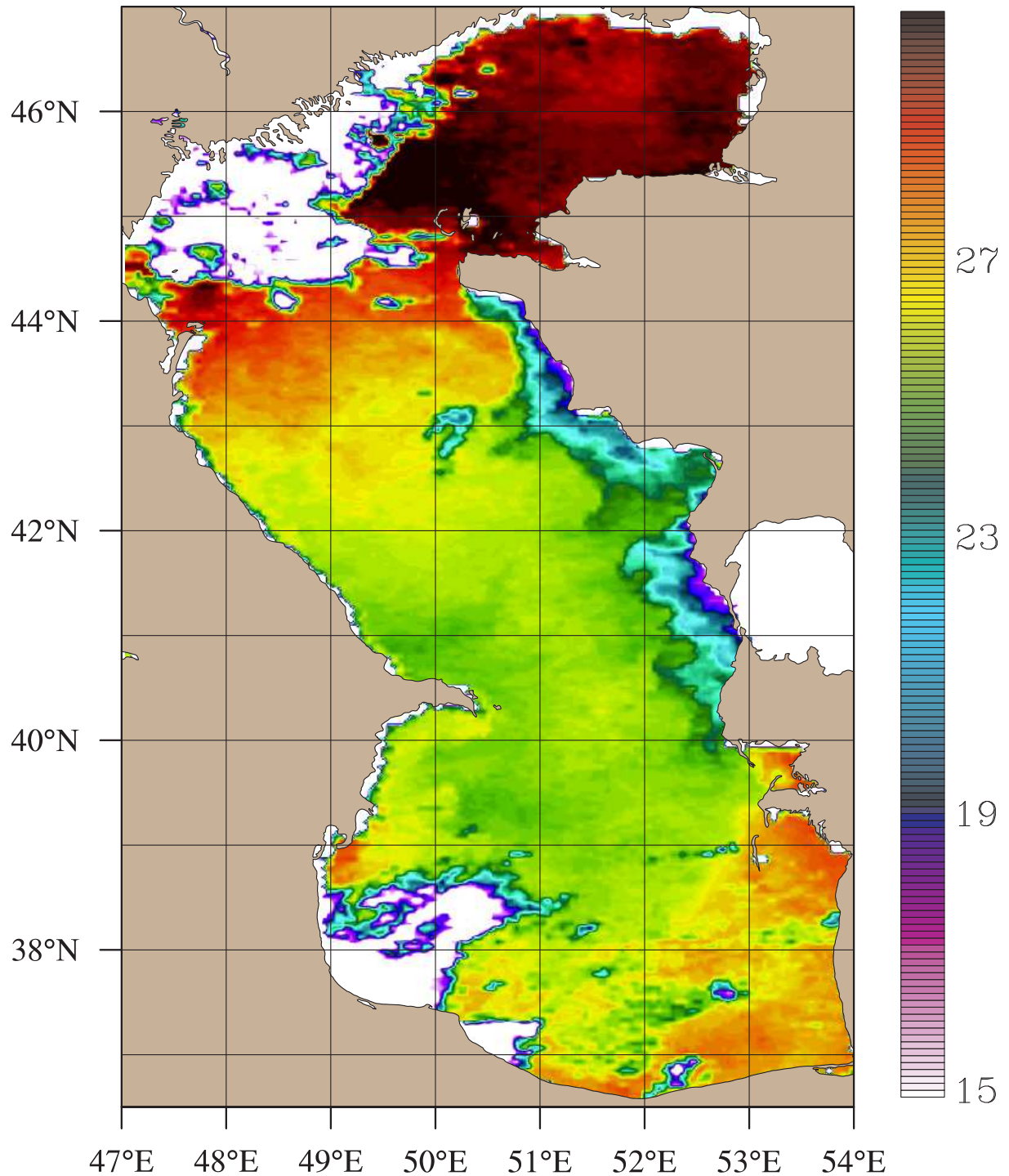- expt 5
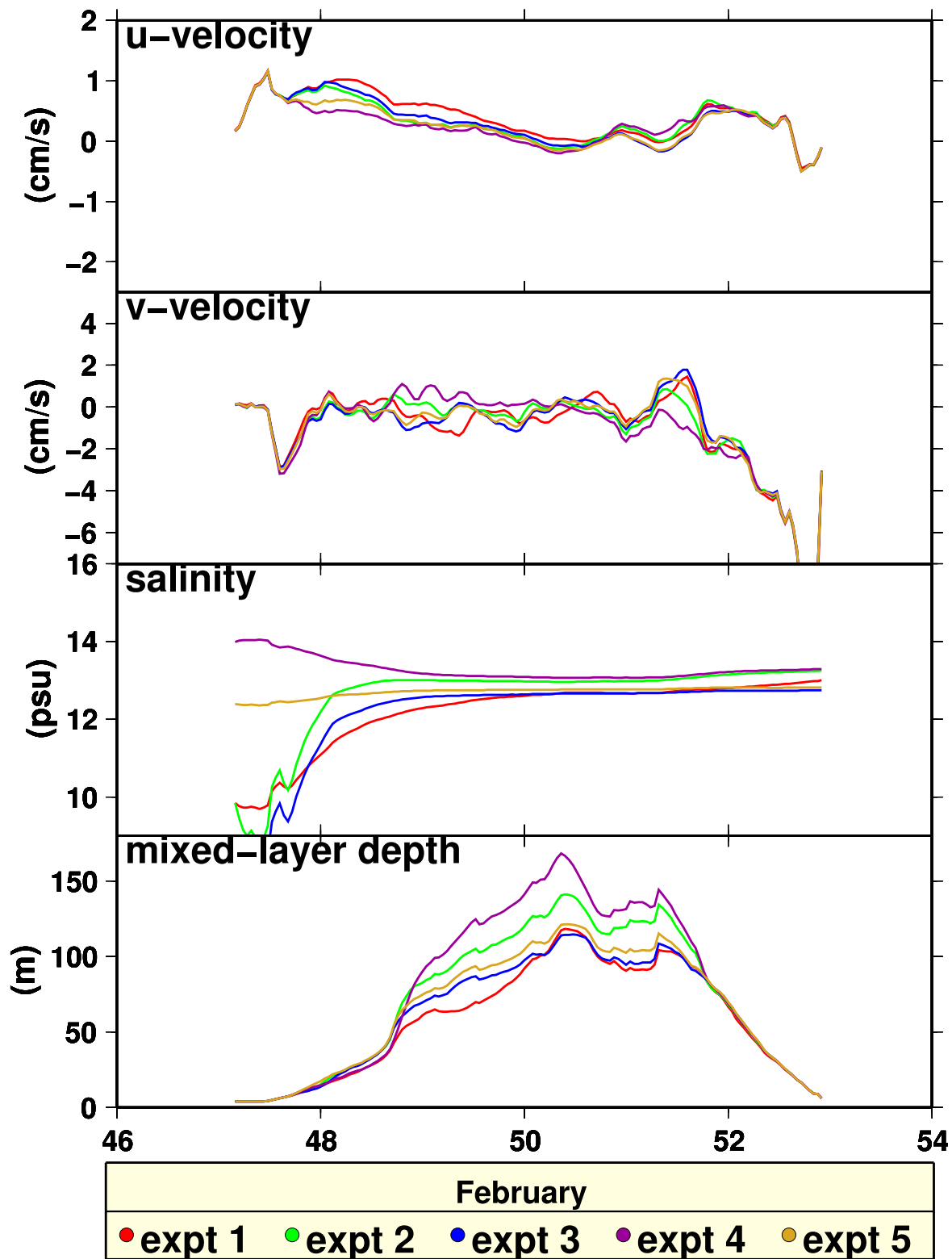
● **Meridional averages of variables from 40.5°N to 45.0°N**

UPWELLING NEAR THE EASTERN COAST

● **Summer SST from AVHRR (16 June 2001)**

AVHRR: Advanced Very–High Resolution Radiometer

MOVIES OF SST

- **Snapshots of daily HYCOM SST from**

    o **25 layer hybrid**

    o **30 level sigma–z**

- **Existence of upwelling near the eastern coast**

- **We typically use daily MODAS SST as truth**

    o **because it is a satellite–based re–analysis product.**

- **However, it is not included in the movies**

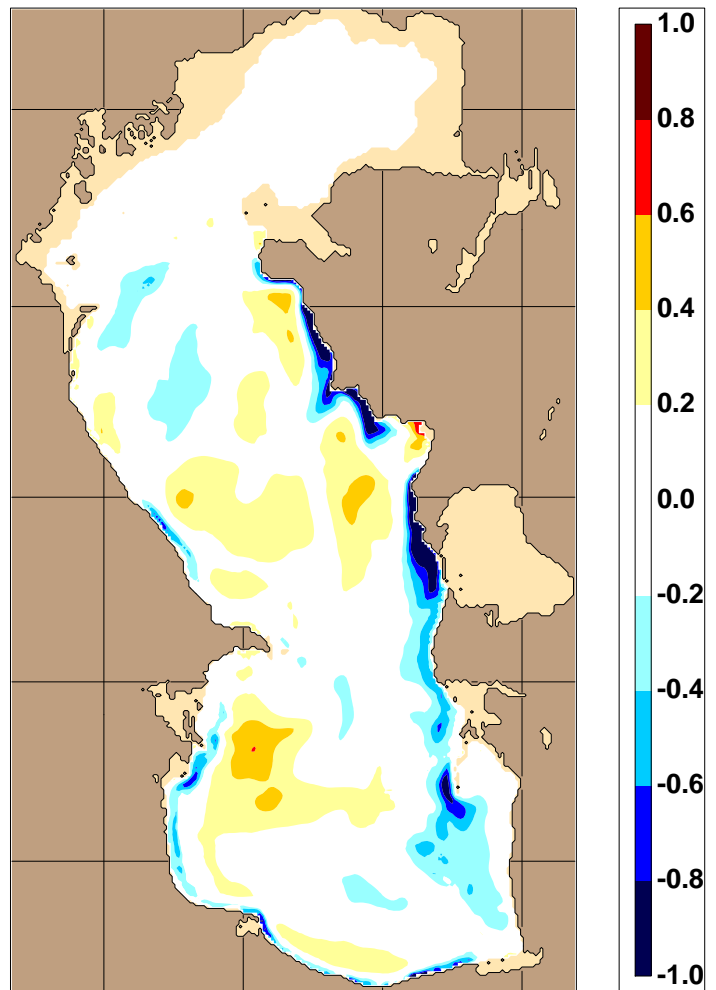   o **because MODAS has no SST in the Caspian Sea.**

ANNUAL MEAN SST BIAS

- **Bias (°C) with respect to 4 km Pathfinder SST climatology**
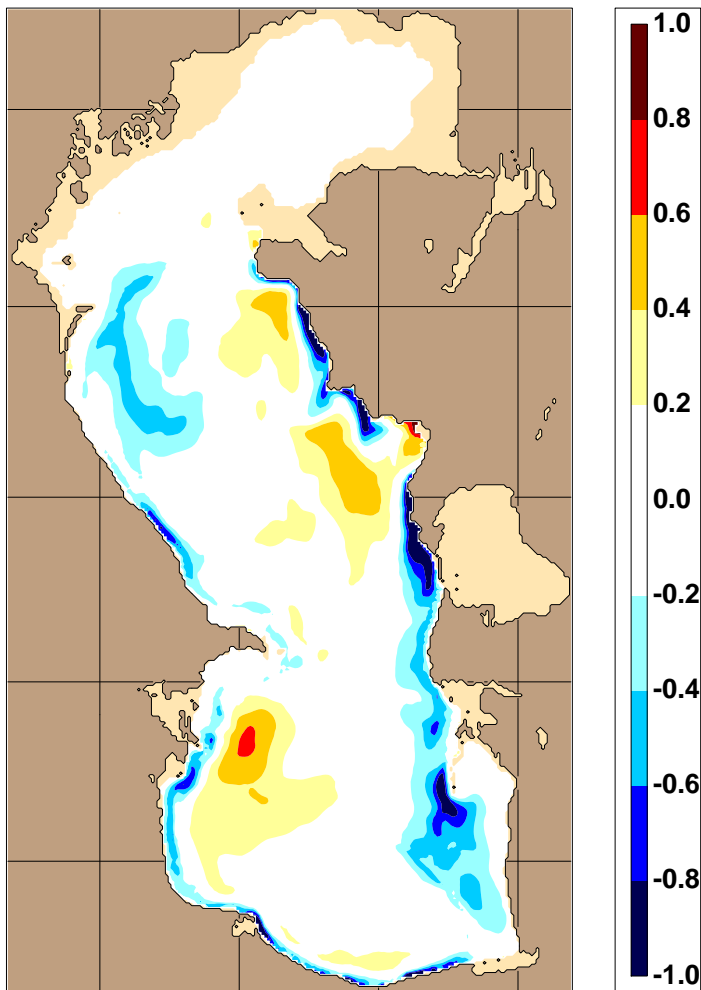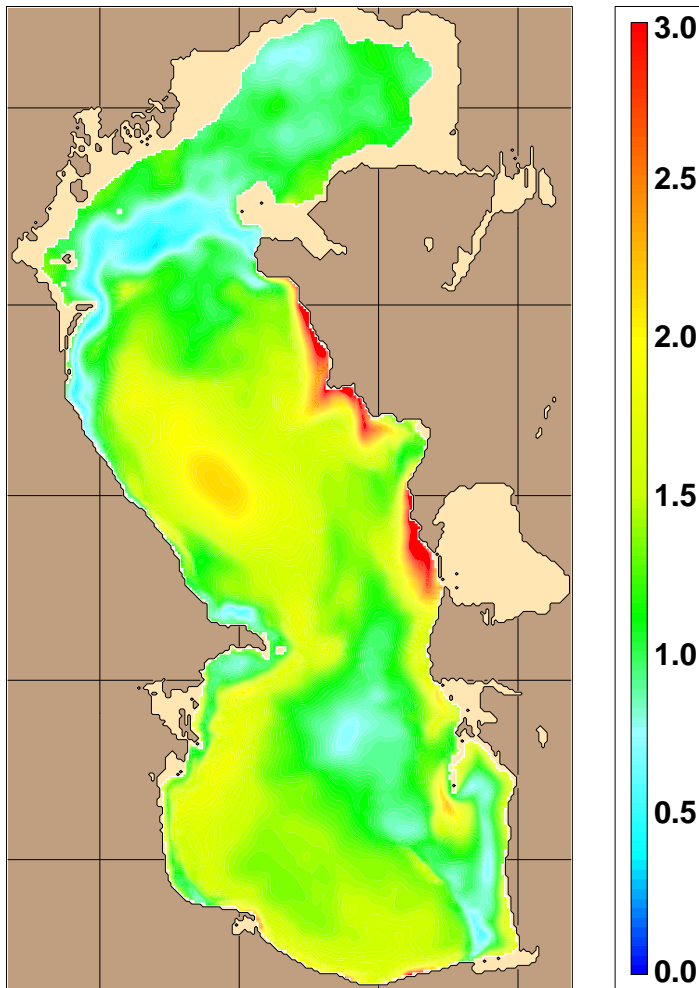
(a) 25 LAYER HYBRID　　　　**(b) 35 LEVEL SIGMA–Z**

- **Basin–averaged SST bias:**

    $\circ \approx 0°C$ **for both simulations**

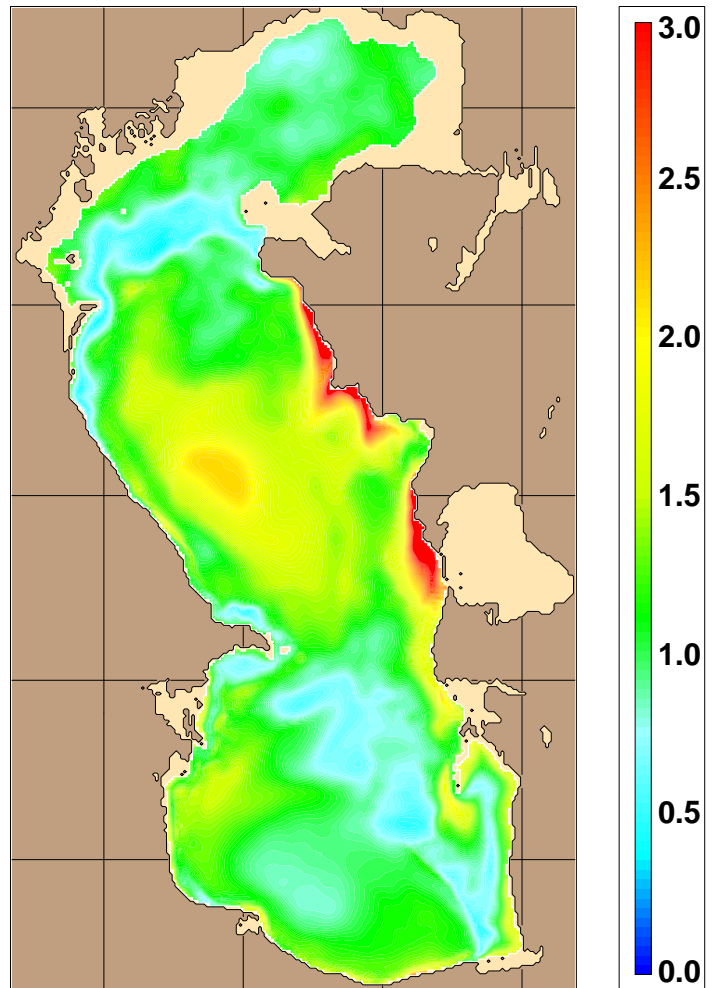- **Large SST error near the eastern coast: Upwelling issues!!**

RMS SST OVER THE SEASONAL CYCLE

- **RMS (°C) with respect to 4 km Pathfinder SST climatology**

(a) 25 LAYER HYBRID

(b) 35 LEVEL SIGMA–Z

- **Basin–averaged RMS SST difference:**

  o 1.4°C (1.2°C) for HYBRID (SIGMA–Z) simulation

SUMMARY and CONCLUSIONS

- **A fine resolution (≈ 3.2 km) HYCOM Caspian Sea model:**

  - o **model set up for hybrid and sigma–z coordinates**

  - o **climatologically–forced simulations (no assimilation)**

  - o **used coarse resolution ($1.125°$) ERA–40 forcing**

- **Initial evaluations for upper ocean quantities:**

  - o **evidence of upwelling consistent with observations**

  - o **net heat flux generally dominates E–P flux**

  - o **SST is well simulated, even with no assimilation**

- **Ongoing studies and future plans:**

  - o **processes controlling upwelling near the eastern coast**

  - o **finer resolution ($0.25°$) European ECMWF forcing**

  - o **inter–annual model simulations (1990 through 2006)**